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Integration of products assessment in mind mapping learning to enhance mathematical communication

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Abstract. Mathematical communication is a fundamental mathematics educational objective. Mathematical communication ability and skills of students in primary school of namely SD 1 Pegunungan Kudus still relatively low because the students has not been given the opportunity to communicate mathematical ideas, orally and written. This study aimed to describe the improvement of mathematical communication ability and skills of 3rd grade students through the application of mind mapping learning that accompanied with product assessment. Classroom action research was conducted on 3rd grade students in SD 1 Pegunungan Bae Kudus. The study lasted for two cycles. Each cycle included planning, action, observation, and reflection. Mathematical communication skill of students was observed based on the observation sheet, whereas mathematical communication ability measured by tests of mathematical communication. The findings are mind mapping learning with product assessment could improve the mathematical communication skills of students from 69.75% in the 1st cycle to 75.52% in 2nd cycle and the average of students' mathematical communication ability has increased from 73.25 in 1st cycle to 85.75 in 2nd cycle. The teacher can add more mathematics problems type that dig students in communicating mathematical ideas so that written, oral and visual mathematical communication skills can be increased.

1. Introduction

Mathematical communication is one of fundamental mathematics objective which consist of ability and skills. Mathematics has a role as a symbolic language that enables the communication effectively. The importance of mathematics because mathematics is a very powerful, thorough, and oriented communication tool [1]. Mathematics is taught in schools to prepare students in developing the ability to use mathematical language to communicate ideas appropriately to solve the situation or problem.

One of mathematics learning goals according to the Ministry of National Education is that students have the ability to communicate ideas with symbols, tables, diagrams, or other media to solve the situation or problem [2]. Students must have the ability in problem solving, reasoning, communication, patterns exploration or relationships, and representation to achieve the content standards [3]. That competency that must be learned and mastered by the students during the learning of mathematics is communicating mathematically (mathematical communication) [4]. Students should be able to express opinions and ideas, both orally and written, as well as other forms and be able to



understand the thoughts and ideas of others.

Mathematics communication is an important part to develop the potential of students in solving problems. Through communication, an idea can be an object that can be reflected as a material that can be discussed and changed [5]. Therefore, Mathematical communication consider people's interactions and exchanges of mathematical ideas, which is a crucial ability for students in expressing their respective mathematical concepts, comprehending and evaluating other students' mathematical equations and thoughts [6]. Teachers should be able to encourage students to be able to communicate mathematical ideas in the learning process. But in fact, many students have not been able to develop mathematical communication skills. Learning is still centered on the teacher. The expository method does not allow students to construct knowledge through direct experience [7]. Students are only considered as passive subjects who should receive information which is important to remember and memorize from the teacher [8]. Students are not involved in the activities and the learning process, they only receive information without questioning why and what they study mathematics for. Students are not given the opportunity to communicate their idea, so they often state that mathematics is a difficult and confusing subject. It also affects the students' mathematics learning outcomes.

Based on the observation and interview with the teacher of grade III primary school namely SD 1 Pegunungan Kudus, students were less interested in mathematics learning process because the teacher has not employed varied approaches and learning methods. Basically, the students' ability in problem solving was good enough, however most students' mathematical communication skills were still low, especially in abstract geometry material that requiring visualization. According to the experience in the previous school year, third grade students had difficulties in solving the mathematics communication ability test. It was difficult for some students to explain the answer. It was seen from the lack of ability of the students in understanding the given problems because they were not used to write things that are known and asked of the question. Some students also had difficulties in interpreting a problem in the form of a graph or sketch. Students also found difficulties in determining the systematic measures due to insufficient understanding of the mathematical concepts.

Based on the issues, it was necessary to do a research which could direct mathematical learning of square and rectangular materials to improve psychomotor aspects in the form of mathematical communication skills in order to improve the cognitive aspects in the form of mathematical communication skills. This could be realized by implementing one of cooperative learning that was a mind mapping learning accompanied with product assessment.

By implementing mind mapping learning, students' memory of factual information could be increased by 10% [9]. Besides, mind mapping learning model helps students to communicate their creative ideas. Application of this model starts from students' discussion a group to solve the problems and presents the results of the group work in front of the class and assessed by the teacher. The presentation can show students' mathematical communication skills. Assessment by teachers is not only a written assessment, but also using the product assessment.

Product assessment is a class-based assessment toward the mastery of students' skills in making a product (process) and the quality of students' work (products). The use of this product assessment is expected to control the students' activities during the learning process so that it can improve mathematical communication ability of students. The average of students' learning outcomes with probing learning-prompting that accompanied by products assessment can achieve learning completeness [10]. Teachers can apply this learning method particularly on geometry material. Students can be directed to create visual aids through products assessment to assist students in finding mathematical concepts while improving mathematical communication ability and skills. The problem in this research was how to increase the students' mathematical communication skills and ability through the application of mind mapping learning that accompanied with products assessment.

2. Methods

The classroom action research was conducted in two repeated cycles in which there were four phases of activities including planning, implementation, observation, and reflection. The research was conducted in 3rd grade SD 1 Pegunungan Kudus academic year 2015/2016.

The data collection techniques used were test and non-test techniques. Tests techniques were used to obtain data of students' mathematical communication ability. The type of tests used were the written tests in the form of a description. Tests were performed twice: at the end of each cycles. Non-test techniques were used to collect qualitative data. The tools used were the observation sheet to observe students' mathematical communication skills.

The data collected in this research included quantitative and qualitative data. The analysis of data was done using quantitative and qualitative analysis [11]. Quantitative data analysis was used to determine the improvement of students' mathematical communication ability while the qualitative data analysis was used to analyze the improvement of students' mathematical communication skills. Data analysis techniques were done through three stages, they were data reduction, data presentation, and conclusions based on the description of the data.

3. Result and discussion

The initial conditions of students in the grade III SD 1 Pegunungan Kudus, that there were problems faced by teacher in mathematics, those were: 1) lack of students' mathematical communication ability and 2) lack of students' mathematical communication skills. Basically, the students' ability to solve problems was good enough, but the most students' mathematical communication skills was still low, especially in the abstract geometry material that required visualization. Moreover, the students' tendency to be shame in the group discussions orally, written, and visually. Some students were not yet complent to express mathematical ideas in group discussions, had been unable to respond protest their friends by giving rational reasons/evidence that ultimately made students in competence to write the conclusion of the obtained results with their own language.

3.1. First cycle

First cycle started from the first phase, the planning phase that included the arrangement of syllabus, lesson plan, students worksheet based on mind mapping learning with the products assessment, visual aids of the square and rectangular circumference, scoring sheet of products assessment, the test plan, the test, and an answer key of mathematical communication ability test of first cycle, observation plan, observation sheets, and scoring sheet of mathematical communication skills.

The second phase of the first cycle was the implementation of mind mapping learning with products assessment. The learning activities began with giving aperception and motivation to attract students' attention, they were: a) students and teachers had an interactive dialogue to ask questions about the benefits of studying the square and rectangular circumference (motivation); b) students observed models of square and the rectangular to recall their characteristics (aperception); and c) the teacher explained the learning objectives and the learning process. In the main activities, teacher and students implemented mind mapping learning with products assessment by the following steps:

1. Students were divided into four heterogeneous groups consists of 4 people, namely the elephant, giraffe, lion and rhino.
2. The teacher divides the worksheets and then explained the tasks to be done by students.
3. Each group of students received worksheets and products assignment that were distributed by the teacher. Cycle I consisted of two meetings. At the first meeting, each group made products to find a formula of square circumference while at the second meeting, they made products to find the rectangular circumference formula. At the stage of making products, the teacher assessed mathematical communication skills by expressing mathematical ideas, either oral, written or visually in group discussion activities. The chairman of the group had been able to deliver oral ideas well, but it was still difficult for them to deliver written ideas. Generally, in the first cycle, students' mathematical communication skills visually were still low, this was indicated by the

number of students who had difficulty in drawing square and rectangular with the appropriate size using a ruler.

4. Students discussed and answered the questions in the worksheet

In this activity, students did group discussions to find a formula of the square and rectangular circumferences by answering constructivist questions in the worksheets scaffolded by the products that had been made. During this activity, the teacher monitored and guided students to construct their own knowledge. In this activity, teacher observed the mathematical communication skills orally.

5. Products presentation and the results of group discussions

Each group posted the results of the discussion on the board, then presented the group's work. Other groups were given the opportunity to respond to the group which was presenting. Teacher gave reinforcement on each group discussions. In this activity, the teacher assessed students' mathematical communication skills in providing a logical reason of the answers given. The leaders of each group were able to communicate their ideas and opinions from the previous discussion, but there were some members of the group that were afraid to communicate in front of the class. Teacher's effort for this problem was to motivate the students in order to participate and express their thoughts on the results of the discussion groups.

6. Students with teacher guidance concluded the formula of square and rectangular circumference.

7. Students did individual quiz.

Individual quiz aimed to determine students' written mathematical communication skills and to know the success of student's learning. Many students could not do the quiz because they did not concentrate in the activity of drawing conclusions. Students could only do measuring without communicating how they used the strategy to find the solution of the problems.

As a closing activity, the students did the final evaluation of the first cycle to obtain data of students' mathematical communications ability of square and rectangular circumference materials. A students score could be stated as complete if the reached Minimum Completion Criteria (KKM) by 75. The learning process of mind mapping with products assessment in the first cycle there were 11 students (68.75%) were declared completing and reaching KKM, while there were 5 students had not completed KKM with a percentage of 31.25% of the number of 16 students. The average of mathematical communication ability score was 73.25 with a highest value achieved by student was 88 and the lowest score was 48. The teacher gave remedial test for the students who got scores below KKM and enrichment for students who reached the KKM. Students and teachers reflected learning outcomes of square and rectangular material. The last activity of teacher was delivering teaching materials for an upcoming meeting.

The third phase of the first cycle was observation. Based on the observations done by the research team, there was an information that the learning process of mind mapping model with the products assessment in the first cycle could improve the communication skills of the students through the activities of the group presentations task in front of the class. From the indicators of communication skills, 71.35% of students understood the problems and evaluated mathematical ideas orally, written, and visually. However, indicators of students' mathematical communication skills that need to be improved was to express mathematical ideas orally, written, or visually (68.36%) and the use of mathematical terms, symbols, and its structures to model mathematical situations or problems (69.06%). The observation result of mathematical students' communication skills of grade III SD 1 Peganjuran found that 7 students (43.75%) were competent, 4 students (25.00%) were highly competent, 1 student (6.25%) were not competent, and 4 students (25.00%) were another competent in mathematical communication. This is because students were still embarrassed when did presentation in front of class about their ideas that had been discussed within the group.

The fourth stage was reflection. Based on the reflection of cycle I, it concluded that there were still some deficiencies during the first cycle, such as: (1) students were still had difficulties in delivering their ideas written; (2) Students' mathematical communication skills visually were still low, this was indicated by the number of students who had difficulty in making square and rectangular images with

the appropriate size using the ruler; (3) some students were still passive and not serious in making the products for relying on friends in one group; (4) there were some unconfident students in the presentation in front of the class. Deficiencies that occurred in the first cycle would be fixed on the second cycle by providing motivation to the students to write down written ideas without being afraid of making mistakes and teacher would give more spirit to students in order to be more confident in the presentation in front of the class.

3.2. Second cycle

Second cycle had the same steps as in the first cycle with some repairs based on deficiencies that occur in cycles I. The first stage was planning that includes the preparation of learning tools and instruments, while the second stage was the implementation of mind mapping learning with products assesment. At the end of the second cycle, the students were given a final evaluation to obtain data mathematical communications ability of square and rectangular material. The type of test used was 5 items of the written test in the description form. From 16 students, to 13 students (81.25%) were completed and reached KKM, while 3 students (18.75%) were incompleted. The highest score achieved by students was 96 and the lowest score was 68. The average of students' mathematical communication ability had increased from 73.25 into 85.75. Graph of improvement of classical mathematical communication ability can be seen in Figure 1.

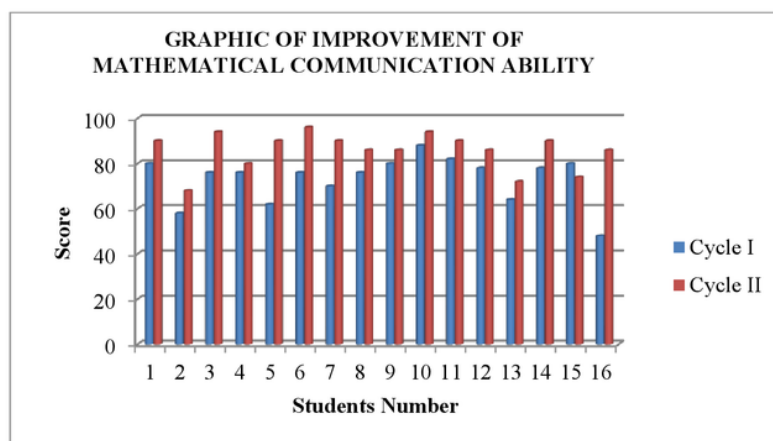


Figure 1. Graphic of Improvement of Each Student's Mathematical Communication Ability

In the third phase of the second cycle, that was the observation of the mathematical communication skills obtaining the data as much as 75.26% of the students understood the problems and evaluated mathematical ideas orally, written or visually that had increased from 71.35%. The indicator that expressed mathematical ideas orally, written, or visually, increased from 68.36% to 79.68% and the indicator of the use of mathematical terms, symbols, and structures to model mathematical situations or problems increased from 69, 06% to 73.13%. Classically, 3 students (18.75%) were rather competent to communicate in mathematics, 6 students (37.5%) were in the competent category, and 7 students (43.75%) were highly competent.

Mathematical communication skills of students in the second cycle increased from 69.75% in the first cycle to 75.52% in the second cycle. Based on the increase of students' mathematical communication result, this study had reached an indicator of success in the second cycle so that the classroom action research was completed in the second cycle. The improvement of mathematical communication skills of each student in Figure 2.

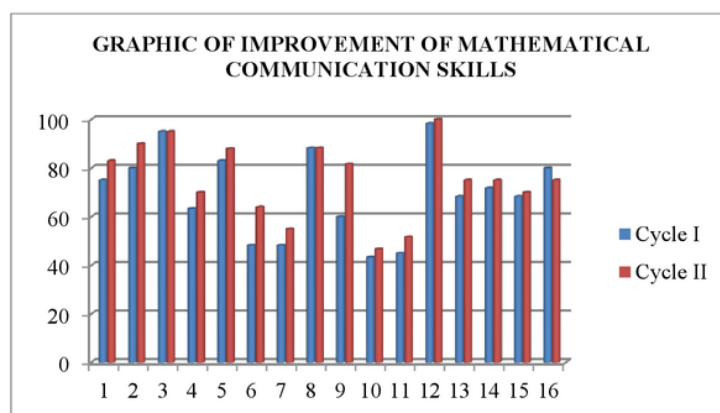


Figure 2. Graphic of Improvement of Each Student's Mathematical Communication Skills

The fourth stage in the second cycle was the stage of reflection. Implementation of mind mapping learning with products assessment in the second cycle had been running better than cycle I. It because students were able to write down their written ideas without any fear of being wrong, and students were more confident to do presentation in front of the class. The achievement of mathematical communication skills and communication skills math showed improvement. Therefore, classroom action research done enough until the second cycle for mind mapping learning with assessment product can improve the communication of mathematics and character of the student's responsibility.

3.3. Students' mathematical communication skill in mind mapping learning with products assessment

Using mind mapping models with product assessment in mathematics of square and rectangular circumference and area materials increased students' mathematical communication skills that seen from the observations results during the learning processes in cycle I and cycle II. Observations data of cycle I indicated that 1 student was not competent in mathematics communication, 4 students were rather competent, 7 students were competent, and the remaining 4 students were highly competent. After the second cycle ended, students' mathematical communication skills had increased from 69.75% in the first cycle to 75.52% in the second cycle.

Mind mapping learning with products assessment made students be able to express oral, written, and visual ideas. During the learning process, the teacher facilitated students to be able to communicate mathematical ideas by creating an appropriate learning environment. Through products task of the invention of the square and rectangular circumference formula, students could understand the problems and evaluated written mathematical ideas. After understanding the problems, students then made the products and sketches so that these improved students' mathematical communication skills visually.

The final result of the products and the discussion of the formula invention were presented by the students to the class. Mathematical communication skills verbally could be improved through group discussions and presentations. It is not only a results presentation, but also training for students to be competent by providing logical reasons of the given answers. Through a discussion with teacher and other groups, students were competent to respond or to protest friends' opinion by giving reasons/evidence rationally. In addition, both groups could verbally express the reasons or evidence to sustain the answer that was considered correct.

Each student who has mathematical communication skills will be able to explain the idea how a mathematical problem can be solved by implementing the strategy coherently and systematically. The problem is not only mathematics problems, but also the problems faced by students in everyday life will be solved critically and logically. Students will be brave to express written, oral, or visual ideas. From the description of the communication skills of the above, it can be concluded that the application

of mind mapping learning model with product ratings can establish mathematical communication skills.

3.4. *Students' mathematical communication ability of students in mind mapping learning with product assessment*

In general, the increase of mathematical communication skills will affect the cognitive outcomes of students, especially in mathematics. When an individual was able to communicate mathematical ideas, it meant that he is able to speak and write about what is being done and understood [12]. Therefore, if the students' mathematical communication skills are increased, students' cognitive abilities are also increased. In addition, the measurement of mathematical abilities made by the teacher should refer to problems that will measure students' high-level thinking skills [13].

Test results data of students' mathematical communication ability grade III SD 1 Peganjuran in the first cycle showed that 11 students were completed and 5 students were incompleting KKM with the score average was 73.25. Reflection stage on the first cycle was not only limited on the remedial of cognitive aspect, but also done to the aspect of responsibility and students mathematical communication skills. The difficulties faced by students in completing the mathematical communication skills test were: (1) students could not understand the problems; (2) students could not sketch square and rectangular images using a ruler; (3) students had difficulties to outline systematic steps to solve the given problem.

Students had been motivated by the teacher to be able to express written ideas on the answer sheets in order to be competent in communicating written ideas. Many students could answer the questions correctly although they could not outline the strategies used in solving problems. Through discussion groups and individual task, students were trained to be able to write things that known, things that asked, the strategies to be used, strategies implementation through systematic steps, to draw conclusions, and to recheck what had been done. This learning process was appropriate with learning theory of Vygotsky which stated that the learning process will occur when children work to handle the tasks that have not been studied [14].

The increase of mathematical communication skills was seen on the evaluation result of the second cycle. The average of students' mathematical communication skills of grade III SD 1 Peganjuran was 85.75, to 13 students completed and 3 students did not complete. Mind mapping learning with products assesment could construct students' knowledge about the circumference and area of the square and rectangular. Students were not given the formula, but they found them themselves through products manufacture.

According to Bruner that good learning outcomes can only be achieved through discovery learning. Discovery learning is to find yourself a learning concept or a particular conclusion [14]. The knowledge gained by discovery learning will be more memorable, has the effect of better transfer, and improve reasoning and the ability of learners to think freely. Implementation of Bruner's learning theory in cooperative learning of mind mapping lies in constructivism which is characteristic of cooperative learning model.

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